

1 **Interpretive Summary:**

2 (Adler) Do farmers' personalities and attitudes influence dairy cattle performance and
3 management? This review reports approaches and results.

4 The question of whether farmers as a person influence animal health, wellbeing, productivity
5 and management has received increasing attention over the past few decades. Attitude and
6 personality are psychological concepts characterizing such intrapersonal factors. The existing
7 literature on dairy cattle was reviewed to determine which approaches scientists have used to
8 answer the question of whether these concepts are such influencing factors. We show that
9 attitude and personality impact on outcomes but also identify aspects of research methods and
10 result presentations that hinder overall conclusions. This review may benefit scientists planning
11 future research and professionals considering mindset-aspects when working together with
12 farmers.

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14 REVIEW: DAIRY FARMERS' PERSONALITIES AND ATTITUDES.

15 **Examining farmers' personalities and attitudes as possible risk factors for**
16 **dairy cattle health, welfare, productivity and farm management: A**
17 **systematic scoping review.**

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ABSTRACT

We aimed to determine how research regarding farmers' personalities and attitudes as risk factors is reported (methodological approaches to assessing, extracting, and processing data and analyzing risk factors) and to explore evidence for the impact of farmers' attitudes and personalities on dairy cattle health, welfare, productivity and management. Therefore, we conducted a systematic review to describe the spectrum of studies on personality and attitude as risk factors for dairy cattle health, welfare, productivity and farm management. Database searches captured 1144 records. 38 were finally included in the review. A tool to systematically extract information was developed, pretested and used to assure the quality and entirety of the extracted information. This review includes publications from 19 countries. Thirty-three manuscripts assessed farmers' attitudes, one assessed their personalities and four assessed both as risk factors. These potential risk factors were checked for relationships with more than 50 different outcome variables regarding farm management (seventeen manuscripts), animal health (thirteen manuscripts), animal productivity (eleven manuscripts) and animal welfare (four manuscripts). The approaches to assessing risk factors and processing and interpreting data varied greatly; thus, drawing conclusions regarding the impacts of attitude and personality as risk factors is impeded, as manuscripts are difficult to compare. Our findings highlight the need for harmonization of attitudes and personality assessments in future research. Furthermore, researchers should carefully consider which depth of detail to apply when planning and evaluating related research. Nevertheless, results highlight the importance of the impact of personality and attitude on outcomes. Farmers' personality and attitudes impact on dairy cattle health, welfare, productivity and management. In general, attitudes indicating higher degrees of technical knowledge, affection with problems, perceived responsibility,

perception of control of a situation , a better human-animal relationship or a positive evaluation of the benefits of management decisions tended to impact in a beneficial way on outcomes. "Agreeableness" and "conscientiousness" were shown promote better farm performance whereas "neuroticism" impacted negatively. Therefore, further research on attitude and personality and their consideration by professionals and decision-makers within the dairy sector and politics is strongly recommended. This might provide the chance to better understand the needs of dairy farmers and therefore develop tailored advice and support-strategies to improve both satisfactory and constructive cooperation.

INTRODUCTION

Good stockmanship is necessary for optimization of health, welfare, husbandry and management, thereby affecting physical and financial performance in animal production (Beynon, 1991). This influence on animal performance in general can occur indirectly by management decisions determining the conditions under which animals live or directly through a certain human-animal-relationship which M.F. Seabrook already reported in 1972 when investigating the cowmans' effect on milk yield in dairy cattle (Seabrook, 1972). The investigation of human-animal-interactions has subsequently led to the construction of new concepts such as human-animal-relationship (HAR) to describe the effects of humans on animals as a part of animal welfare studies. HAR has become one of the most widely used concepts with respect to explaining human influence on animal welfare. It is based on the assumption that animals fear humans (Hemsworth, 2003). The level of fear in farmed animals has been shown to impact on their performance for various species (Hemsworth et al. 1981; Barnett et al., 1992; Cransberg et al. 2000; Hemsworth et al.; 2000). It has also been shown that the way stockpeople interact with their animals has strong effects on the level of stress and fear animals experience (Hemsworth et al., 1989; Jones, 1993). Today, stockmanship, in general, is proposed to consist of three essential traits: animal husbandry knowledge, animal husbandry skills and personal qualities (Department for Environment, 2007). The fact that personal qualities are seen as a main trait of stockmanship is a result of researchers, in addition to the investigation of environmental risk factors, paying increasing attention to the farmers or stockpersons themselves regarding their influence on farm animal well-being and performance (Beynon, 1991). Hence, it is important to understand which person-intrinsic determinants might lead to farmers deciding or acting in a certain way; socio-psychological approaches have therefore emerged in veterinary and animal science research. These approaches assess human-intrinsic influences, including personal qualities. However, within this research, diverse terms have been used to characterize these personal qualities of interest. "Personal characteristics"

(Waiblinger et al., 2002), “ethical positions” (de Rooij et al., 2010), “empathy” (Kielland et al., 2010), “perceptions” (Vaarst and Sorensen, 2009), “mindset” (Scherpenzeel et al., 2016), “attitude” (Bruijnis et al., 2013) and “personality” (Hanna et al., 2009). This diversity reflects underlying variation, including:

- Use of different approaches to capture the stockmen's personal qualities.
- Different theoretical backgrounds underpinning exploration of the concepts of farmer-intrinsic risk factors.
- Knowledge of assessment methods and results interpretation are required to evaluate the significance of the findings and the importance of stockman-intrinsic risk factors.

Existing literature revealed that the psychological concepts, “personality” and “attitude”, were consistently used to label personal qualities. Several socio-psychological research publications were available regarding these concepts' theoretical backgrounds. In preparing for a nationwide cross-sectional study on dairy herd health and performance we therefore focused on these two concepts to investigate how they impact on dairy cattle health, welfare, productivity and farm management.

Prior to assessing the impact of attitude and personality on these outcome themes it is important to define and describe the theoretical backgrounds of these concepts:

Personality refers to individual differences in characteristic patterns of thinking, feeling and behaving (adapted from Encyclopedia of Psychology). Personality psychology is “the study of what makes a person unique from others” (Feist, 1998). In contrast to attitude measures, which are context dependent (Schwarz, 2001), personality traits remain relatively stable after a person reaches age 30 (Costa, 1994). Psychologists capture human personality in predefined domains, which have been characterized in lexical studies, which identify the most salient aspects of human personality based on these aspect's representation in a language's lexicon (Saucier, 2001). The names and numbers of domains and subordinate facets finally representing human

personality differ depending on the framework considered. For example, the Big-Five framework is popular and is the most widely used and extensively researched personality model. This framework classifies individual personality differences into five broad empirically derived domains (Gosling et al., 2003). Each domain includes six subordinate facets.

In contrast to the Big-Five framework, other researchers argue that a six-factor-structure better describes personality variations (de Vries et al., 2016); thus, the HEXACO-model was developed. However, regardless of the overall number of domains and facets included in a framework, psychologists have shown that personality dimensions can predict human behaviors such as health behavior (Booth-Kewley, 1994). Irrespective of the framework considered, approaches to assessments are the same; respondents are provided with a number of descriptive statements to rate on a Likert Scale in most validated inventories.

Attitude, however, represents a summary evaluation of a psychological object (Ajzen and Fishbein, 2000). Psychological objects are the objects that psychologists choose to investigate (Danziger, 1993). This expression is therefore used synonymously for "attitude object" here. Every attitude must be related to one specific psychological object (Ajzen, 2001). In assessing attitude, psychological objects can be physical objects (e.g., dairy cows), theoretical questions (e.g., importance of calf-rearing practices) or behavioral options (e.g., adopting certain farm management practices). Assessment of a person's attitude towards an object requires that the object is presented to that person for evaluation. This can be done by direct and indirect measurement. A common approach to direct measurement is to provide the respondent with statements related to the attitude object. The respondent would then agree or disagree with that statement using a Likert or semantic differential scale. Indirect measurements use projective techniques, presenting the person with ambiguous or incomplete stimuli (e.g., pictures or open-ended qualitative interview questions) that require interpretation or lead to narrative material around the psychological object of interest. The person's attitude is then inferred by how they

respond (McLeod, 2009). In both direct and indirect measurement, the researcher must extract and interpret the attitude information by applying suitable data processing and analysis techniques.

Attitude is an important research area, as attitudes can predict behavior (Ajzen, 2001). Two prominent theoretical frameworks underpinning this are the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB; Ajzen, 1985; Kauppinen et al., 2013). However, another important aspect is that attitudes can change; motivation and capacity are assumed to be required for such a change (Wilson et al., 2000). Farmers' attitudes, therefore, are potential targets for external stimuli (e.g., veterinary consultancy, intervention programs) aiming to change behavior to improve the animals' situation or farm productivity. For example, the positive effect of a cognitive behavioral intervention program on attitude and behavior of dairy stockpeople has been reported by Hemsworth et al. (2002).

In order to investigate the impact of personality and attitudes on dairy cattle health, welfare, productivity and farm management, we conducted a systematic scoping review of the related literature. In contrast to a systematic reviews seek to appraise and synthesis research evidence, scoping reviews aim to assess and identify the scope and nature of research related to a specific topic (Grant et al., 2009). The review was conducted focusing on three objectives:

(1) Describe the **spectrum of studies on personality and attitude as risk factors** for dairy cattle health, welfare, productivity and farm management.

(2) Describe **whether risk factors (personality and attitude) are related to (which) dependent variables**.

(3) Examine whether **overall contextual conclusions** can be drawn on the impact of farmers' attitudes and personalities on dairy cattle health, welfare, productivity and management.

MATERIALS AND METHODS

Based on PRISMA-statement recommendations (Liberati et al., 2009) and guidelines proposed for conducting scoping reviews (Colquhoun et al., 2014; Peters et al., 2015) the existing literature was systematically reviewed to provide a structured overview of research on farmers' personalities and attitudes as risk factors for dairy cattle health, welfare, productivity and management. The review was focused only on the risk factor analyses that consider personality and/or attitude as (human) risk factors for an outcome related to animal health, welfare, productivity and management conditions. Welfare is a multidimensional term including an animals' physical and mental state defined by the "five freedoms" (Department of environment, 2007). From this perspective it might also cover aspects related to other thematic areas of dependent variables (i.e. health, productivity). Nevertheless, for this review, it was decided to consider "health" and "productivity" as independent thematic areas for the purpose of clear discrimination and to be able to define eligibility criteria (see below). We did not perform a meta-analysis due to the wide scope of our approach. Furthermore, we did not focus on intervention strategies associated with personality and attitude; this would be a useful second step after identification of the role of personality and attitude traits as risk factors. Instead, we describe the scope of research and general findings and present aspects related to methodological approaches and results presentation and interpretation which may be considered in future research.

Search and extraction strategy

Eligibility criteria were defined prior to the study. The review includes peer-reviewed journal articles on dairy cattle of all breeds and ages. Languages were limited to English and German. Geography and publication year were not restricted. Personality or attitude had to be explicitly mentioned in the title, abstract or keywords and had to be reported as risk factors for one or more dependent outcomes of interest. Specifically, dependent variables had to be related to animal health (e.g., disease prevalence, somatic cell counts), productivity (e.g., milk yield, milk contents), farm management (e.g., on-farm management decisions and farmers' behaviors

towards animals) and welfare. Welfare in the context of this review covers the animals' mental state (e.g., aversive behavior indicating stress). Assessments had to be performed by clinical examination or scoring the animals or evaluation of their behavior, the farmers' behavior, farm-performance data, data collected by the farmers on the farm, pre-existing data from external sources (e.g., health monitoring programs) or assessing information from questionnaires or interviews.

Web of science, PubMed and CAB Abstracts were used as search databases. Searches were performed in German and English.

The **search strategy** was identical for all three databases. Known relevant literature was used to develop search-strings. Sensitivity analysis was performed by testing different combinations of concepts and keywords in all three databases. Concepts were modified by the outcome to make sure all relevant literature was captured. Terms which did not contribute to improvement of the queries were dismissed. For example, terms included in explorative searches like "cowman" and "animal-keeper" (concept I) and "trait*" (concept II) were removed as they did not improve search performance.

Tables 1 and 2 indicate the final search-concepts and keywords included in the search strings. The final search in English was conducted on 24 April 2017 (Web of Science, Pub Med and CAB Abstracts up from 1989) and on 10 May 2017 for CAB Abstracts 1910-1989. The final search in German was conducted on 10 May 2017 in all three databases. By the end of the revision process, an update was performed running the search in all three databases once more on 5 December 2018.

Study selection was performed in three stages. First, the title, abstract and keywords from the papers captured by the final database searches were screened. The terms "personality" or "attitude" or both had to be explicitly mentioned and considered potential influencing factors. Outcome variables had to be related to dairy cattle health, welfare, productivity or farm

management. Second, after removing duplicates, full texts were then checked for relevance in detail. Finally, reference lists of the eligible papers were checked for potential missing records.

We developed an a priori data sheet to **extract information** from the included full texts, using Microsoft ExcelTM (Redmond, WA, USA). The sheet was piloted by the first author on five randomly-selected included papers and refined accordingly until the data sheet captured all pertinent information relating to the review's objectives. To prevent observer bias, data were extracted independently and in duplicate by the first author and two colleagues. Differences in extracted information were discussed by involving the last author to reach consensus.

Extracted information

The final data sheet consisted of 22 items. Three were included to internally manage data ("consecutive number of the record", "record included in data extraction" [yes or no] and "record's citation").

To describe the **study spectra on personality and attitude as risk factors**, descriptive characteristics of the published research were extracted: "country of research", "personality assessed" (yes or no), "attitude assessed" (yes or no) and "dependent variables assessed". Per the predefined dependent variable categories, the "dependent variable category" (health, welfare, productivity, or management) was extracted. Whether the "theoretical framework for personality or attitude [was] explicitly named" (yes or no) was documented. Furthermore, the methodological approaches to assessing personality ("personality model applied or facets assessed", "instrument used to assess personality") and attitude ("instrument used to assess attitude", "attitude-items considered individually or attitude-classes generated", "attitude classes assessed or extracted from the items", "statistical method for generating attitude-class" and "method used to analyze risk factors" were documented. "Number of items and scales provided" was extracted concerning the assessment of personality and attitude. As attitudes are connected to specific psychological objects (Ajzen, 2001), this was extracted as well

(“psychological object”). At this point, the exact wording used to label the psychological objects was extracted from the records without adding any interpretation concerning their meaning. Subsequently, psychological objects were aggregated into generic terms and topics.

To determine **whether risk factors (personality and attitude) are related to (which) dependent variables**, “relationship between attitude and dependent variable” and “relationship between personality and dependent variable” (yes or no) were extracted.

We assessed possible factors that may hinder an **overall conclusion** on the impact of attitudes and personality. Focus was on data collection and processing (e.g., summing up information on attitude or personality in scores or latent data) and on conducting risk factor analyses. Additionally, the disclosure of questions/items used for risk factor analyses was assessed (“Items used for personality assessment made accessible” [yes or no] and “Items used for attitude assessment made accessible” [yes or no]).

RESULTS

Spectrum of studies on personality and attitude as risk factors

In total, 1144 records were captured by the search strategy. Figure 1 illustrates the paper selection steps and the number of studies excluded at each step. The main reasons for excluding records were: (1) presenting only descriptive results on personality and attitude, (2) considering attitude as an outcome, (3) considering outcomes, which were not meeting the eligibility criteria (4), investigating effects of intervention aiming to change attitudes and (5) dealing with beef cattle.

In all, 38 records meeting eligibility criteria were identified and included in the review. The completed data extraction sheet can be accessed as supplementary material (Supplemental Table S1; <http://dx.doi.org/10.3186/jds.20XX-XXXXX>). Publication years ranged from 1972 (Seabrook, 1972) to 2017 (DeLong et al, 2017; Kayitsinga et al., 2017). Most publications

assessed attitudes as risk factors (n=33; 86.8%), four publications assessed attitude and personality (n=4; 10.5%) and one assessed personality only (n=1; 2.6%). Research on the effects of farmers' personalities and attitudes on dairy cattle health, welfare, productivity and management as far as captured by this review includes data from 19 different countries. Half of this research was conducted in the United Kingdom, the Netherlands and Norway (n=19; 50%; Table 3). The dependent variables were related to dairy cattle health (n=13 publications), welfare (n=4), productivity (n=11) and farm management (n=17).

Theoretical background. Four of five papers investigating **personality** presented at least basic information on the theoretical background underpinning their assessment. Three of five articles referred to the Big-Five personality traits as a basis for their assessment. Waiblinger et al. (2002) and Seabrook (1972) indicated no specific theoretical background behind their personality assessment. Only Alvarez and Nuthall (2006) presented explicit theoretical backgrounds on the relationship between personality and outcome variables, referring to the Information Innovation Adoption Model (Agarwal and Prasad, 1998).

Theoretical background for assessing **attitude** grounded in socio-psychological research was provided in 48.7% (n=18) of the papers. Theoretical backgrounds explicitly mentioned were the Theory of Planned Behavior (n=5), Theory of Reasoned Action (n=5), Health Belief Model (n=1), Behavioral Economics (n=1) and Social Ecology Model (n=1). Two papers referred to more than one theory. Papers not explicitly mentioning the theoretical background behind their research provided citations leading to corresponding social science information (n=6). Finally, 50% (n=17) of papers provided no information on the socio-psychological background.

Data collection. Four of five studies assessing farmers' **personalities** employed self-report questionnaires. Within the publications included (n=5), eleven personality domains were assessed (Table 4). For that purpose, Hanna et al. (2009) obtained a questionnaire from the International Personality Item Pool (<http://ipip.ori.org>; 2001), while Arias and Spinka (2005)

employed the Czech standard short version of the NEO Big-Five Personality Inventory adapted from Costa (1992). Alvarez and Nuthall (2006) employed a locally developed item set to assess the Big-Five personality domains. Waiblinger et al. (2002) and Seabrook (1972) did not use a conventional personality test but rather a self-developed item set. All questionnaires, except the one used by Seabrook (1972), included a set of statements to be rated by the respondent. Each statement coded for one specific personality domain only; however, each domain could be assessed through several statements. The number of statements coding for a domain depended on the questionnaire. To rate the items, Hanna et al. (2009) and Arias and Spinka (2005) provided Likert scales to the respondents. Waiblinger et al. (2002) operated a semantic differential scale. Alvarez and Nuthall (2006) did not report the scale used to rate the questionnaire items. Seabrook (1972) initially provided respondents with questions during structured interviews, however this approach, turned proved to be inappropriate when piloting it. Consequently, an approach based on the "play technique" was used.

Psychological objects were of interest in assessing attitudes. Given that exact wording was taken as presented in the papers without interpreting textual meanings, 35 psychological objects were assessed. Fourteen studies (37.8%) reported to have investigated attitudes towards more than one psychological object. Most studies investigated attitudes towards animal diseases, their diagnostics and therapy (n=20; Table 5).

Twenty-five papers (67.6%) reported having used questionnaires completed by respondents. Questionnaires were completed in person during farm visits (n=11) or sent to respondents by post (n=9) or email (n=1). In one further study, respondents could answer the questionnaire online only, and three other papers reportedly let the respondent decide whether to answer on paper or online.

Eleven papers (29.7%) used interviews to investigate attitudes. Nine (81.8%) conducted interview questionnaires face-to-face (n=5) or via telephone (n=4). Two papers (18%) reported

using semi-structured face-to-face interview techniques. One paper reported conducting farm visits and studying stockpeople based on the "play technique" (Seabrook, 1972).

The number of items presented to the respondents ranged from a single item to 157 (Waiblinger et al., 2002). Seven papers (18.9%) did not indicate the number of items included. Based on existing information, the average number of items was 24. For quantitative approaches, Likert scales were used most frequently (91%; n=31 papers). In one study (Alemayehu et al., 2010), researchers asked respondents to answer a question on a binary (yes/no) scale. Two papers (6%) did not indicate which scale was used.

Interviewees' responses to open-ended questions included in qualitative interviews were audio recorded and transcribed word-for-word to extract subsequent information (Heffernan et al., 2008; Vaarst and Sorensen, 2009).

Item disclosure. No papers provided the complete wording of the items used to assess **personality** data. Two papers referenced these items by citing other studies or technical literature (Arias and Spinka, 2005; Alvarez and Nuthall, 2006). Hanna et al. (2009) presented a web link to the questionnaire used; however, this link was inactive when we tried it. Waiblinger et al. (2002) provided one example from the 14 statements they used to assess personality.

Twenty papers (54%) that investigated farmers' **attitudes** disclosed all items in text or tables (n=19) or in supplementary material (n=1). Seventeen (46%) provided no comprehensive information on the items used. One paper (Schewe et al., 2015) included a web link for that purpose; however, it was inactive at the time this review was undertaken.

Information extraction and data processing. Information on extracting **personality** dimensions and processing data to assess personality was presented in two of five publications (Waiblinger et al., 2002; Arias and Spinka, 2005). Arias and Spinka (2005) provided stock-people with a questionnaire containing 60 self-description items to rate on a five-degree scale,

ranging from “fully agree” to “fully disagree”. Twelve items represented each personality dimension. To measure each of the four dimensions, the average score was calculated from the twelve items coding that dimension. Waiblinger et al. (2002) used Principle Component Analysis and Varimax Rotation to reduce the 14 self-descriptive items in their questionnaire. The result was three components representing personality dimensions, which were labelled as “agreeable”, “confident-extravert” and “pessimistic”.

Attitude information extraction and data processing methods differed between studies depending on the technique used to obtain the primary data. Two major approaches to extracting attitude information in quantitative research were found. Twenty-five papers (73.7%) condensed items into smaller numbers of attitudes classes or into an overall attitude. Six (17.7%) considered each questionnaire item in the risk factor analysis. Two papers (5.8%) combined both approaches. One paper (Bertenshaw and Rowlinson, 2009) provided no comprehensible information on information extraction.

Principle component analysis (PCA) was the most common procedure for condensing attitude items (52%; n=13), followed by summing single item scores to calculate a final attitude score (16%; n=4). Other papers used procedures such as factor analysis (Vande Velde et al., 2015; Fukasawa et al., 2016), structural equation measurement models (Toma et al., 2013; Toma et al., 2015) or transforming a five-point Likert scale into a dichotomous outcome (Kielland et al., 2010).

Content analysis (Heffernan et al., 2008) and a modified grounded theory approach (Vaarst and Sorensen, 2009) were used to code information from semi-structured interviews. Seabrook (1972) used records (e.g. percentage distribution of comments made by stockmen, stockman cow interactions) to extract attitude information by comparing the different stockmen.

Risk factor analysis. After extracting **personality** dimensions, risk factor analysis was conducted using Spearman correlation (Waiblinger et al., 2002; Arias and Spinka, 2005) and partial correlation analysis (Hanna et al., 2009). Alvarez and Nuthall (2006) looked for direct relationships between personality dimensions and outcome variables by the t-test, Mann-Whitney U test and Chi-square test. Only variables directly affecting the outcome variables were included in a structural equation model. Correlation coefficients or standardized regression weights were used to investigate relationships between personality dimensions and outcome variables.

Diverse statistical methods were used to analyze risk factors investigating **attitudes**. Correlational analysis (e.g., Spearman correlation, Pearson correlation, and partial correlation analysis) and regression analysis (e.g., linear regression, logistic regression, and regression tree analysis) were the most frequently mentioned approaches, followed by structural equation modeling.

Vaerst and Sorensen (2009) conducted semi-structured qualitative interviews to assess attitudes, using modified grounded theory to extract attitude themes. They compared two groups of farms (high versus low calf mortality) relative to the attitude themes farmers mentioned during their interviews. Related conformities and differences were analyzed to evaluate the impact of attitude on calf mortality.

Relationship between personality and dairy cattle health, welfare, productivity and management

Three of the five studies assessing farmers' **personalities** reported it to be at least partially related to the dependent variables. When Waiblinger et al. (2002) assessed three personality components ("agreeable", "confident-extravert", and "pessimistic"), only "agreeableness" was significantly negatively correlated with the percentage of farmers' neutral and negative behaviors towards cows. In contrast, "agreeableness" was positively correlated with farmers'

positive behaviors towards cows during milking. Arias and Spinka (2005) reported that “neuroticism” in stock-people was negatively correlated with average herd milk yield in kg per standardized lactation, and also positively correlated with mean veterinary care costs per dairy cow and year on the farm. Neuroticism, here, is defined as emotional lability (Roccas et al., 2002). This dimension can be divided into six facets (anxiety, anger, depression, self-conscientiousness, immoderation and vulnerability).

Conversely, “conscientiousness” was negatively correlated with veterinary costs. This dimension comprises the facets self-efficacy, orderliness, dutifulness, achievement striving, self-discipline and cautiousness thus representing a persons' tendency to be careful or vigilant (Roccas et al., 2002). Seabrook (1972) found the personality of stockmen to impact on milk yield and suggested that this was because some farmers achieved a better human-animal relationship on their farms.

Although they assessed the same Big-Five personality traits as Arias and Spinka (2005), Hanna et al. (2009) identified no relevant direct correlation between personality domains and milk yield. Furthermore, Alvarez and Nuthall (2006) revealed no relevant direct relation between personality domains and farmers adopting computer-based information systems.

Relationship between attitudes and dairy cattle health, welfare, productivity, and management

Table 6 provides an overview of reported relationships between dependent variables sorted by thematic areas and **attitudes**. Extracting the exact wording for psychological objects from the records led to diverse combinations of attitudes and dependent variables. Therefore, it was impossible to determine reported relationships between all dependent variables and attitudes. More than 50 dependent variables were investigated overall. Four of 37 papers (10.8%) found no relevant relationships between attitude and dependent variables. In the following, despite differing methodological approaches, we highlight findings on attitudes' impact from the

reviewed studies within the different thematic outcome areas. These will be discussed later on concerning their possible consideration for future research or professionals in the field.

Impact of attitudes on animal health. The impact of attitudes on milk **somatic cell counts** was investigated within various studies. Schewe et al. (2015) and Jansen et al. (2009) showed that somatic cell counts were associated with farmers' attitudes towards mastitis. Higher cell counts were shown to be positively associated with the farmer seeing mastitis and not following milking- and treatment protocols as a problem on his farm (Schewe et al., 2015). Furthermore, the farmers' perception of control over the problem was revealed to be negatively correlated with cell counts (Jansen et al., 2009; DeLong et al., 2017) and the incidence of clinical and subclinical mastitis (DeLong et al., 2017). In addition, Tarabla and Dodd (1990) showed that farms on which the stockperson evaluated the task of milking as positive (i.e. positive attitude towards milking) were less likely to show high cell counts.

A positive attitude towards **calf mortality** and **calf disease** (i.e. the farmer feeling in control of the situation) was shown to negatively impact on farms' calf mortality rates (Vaarst & Sorensen, 2009). Santman-Berends et al. (2014) revealed that farmers who reported to see a dead calf as a problem to have lower mortality rates and those considering a stillbirth from a cow more severe than a stillbirth from a heifer to have higher rates. Silverlas et al. (2013) found an association between positive attitudes towards biosecurity (i.e. considering biosecurity as important) and lower **cryptosporidial** prevalence in calves on farms. Kielland et al. (2010) investigated the impact of farmers' attitudes towards pain in cattle on the prevalence of **lesions on the hock and carpus of cows**. Farmers indicating agreement to the statement "animals feel pain as humans do" were more likely to have low prevalence of hock and carpus lesions on their farms. Furthermore, the prevalence of **lame cows** was shown to correlate with attitudes towards cows (Rouha-Mulleder et al., 2009). Prevalence increased with farmers indicating a higher intention to use negative behavior when moving cows and decreased with farmers'

reporting dislike of such negative behavior. Broughan et al. (2016) showed the odds of being a **bovine tuberculosis (bTB) case** to be associated with farmers' attitudes towards bTB. Farmers' seeing their animals less under threat of other cattle as possible carriers of the disease and being less likely to think that other people or institutions could help them to solve the problem of bTB had higher odds to be a case farm.

Impact of attitudes on welfare. The impact of stockpersons' attitudes on dairy cattle welfare was investigated by studying the behavior of cows in presence of humans. Assessing the impact of stockpersons' attitudes towards "characteristics of cows" and "working with dairy cows", Breuer et al. (2000) reported that positive attitudes towards cows were negatively correlated with **aversive cow behavior** (i.e. flinch-, step- and kick-responses) in the milking parlor. De Roches et al. (2016) revealed that farmers with a more negative behavioral attitude towards cows had a lower proportion of **cows accepting to be touched** in a standardized avoidance distance test.

Impact of attitudes on productivity. **Milk yield** and **milk contents** were investigated concerning their relation to farmers' attitudes in various studies. Attitudes towards cows (i.e. cows' characteristics and working with dairy cows) were the psychological objects used most frequently within this research area. Employing the same questionnaire items and answer scales to assess attitudes, Hanna et al. (2009) extracted four factors ("empathy", "negative beliefs", "job satisfaction" and "patience") from the raw data, whereas Fukasawa et al. (2017) extracted only three ("positive beliefs", "negative beliefs" and "job satisfaction"). Risk factor analysis findings also differed. Fukasawa et al. (2017) found only "positive beliefs" to be positively related to milk yield. In contrast, while Hanna et al. (2009) found the attitude classes, "empathy" and "job satisfaction", to be positively correlated with milk yield, no such correlation was found for milk yield and "patience". "Negative beliefs", however, negatively impacted on milk yield. The association between job satisfaction and milk yield is in compliance with Seabrook (1972)

who found attitudinal factors related to job satisfaction (i.e. perceived level of stress, motives, emotion) to be associated with milk yield. Breuer et al. (2000) found a positive composite attitude towards cows (including items related to petting and talking to cows, ease of movement of cows and the ability of cows to recognize unfamiliar stockpeople) to be positively correlated with milk yield and protein contents, while Kauppinen et al. (2013) did not find any associations between farmers attitude towards improving animal welfare and milk yield. Nor did Arias and Spinka (2005) reveal any associations between farmers' attitudes towards dairy cows and productivity.

Attitude and farm management. Bruijnis et al. (2017) found farmers' positive attitude towards the belief that foot health could really be improved by taking action to be positively correlated with their reported intention to improve cow foot health. Toma et al. (2015) aimed to identify attitudes modulating farmers' behavioral willingness to control **E. Coli infections** on their farms. Knowledge about the pathogen, the feeling of responsibility and former experience with related infections on the farm were identified to be drivers that positively impacted on farmers' willingness to take action. Conversely, Heffernan et al. (2008) did not reveal any comprehensible relationship between attitudes towards individual versus collective **biosecurity behavior** and attitudes towards biosecurity regulation and participation in bio-security collective action among farmers. Also related to the biosecurity aspect, Ritter et al (2015) investigated whether farmers participated in a voluntary management-based **Johne's disease** control program. Attitudes towards the disease and the control program were considered potential influencing factors. The results showed participants to have higher self-assessed knowledge of Johne's disease and better understanding of the control programs' details. Non-participants' attitudes indicated time to be a major on-farm constraint and those farmers stated that participation in the program would take them too much time.

Other research was concerned with management decisions related to therapy of diseases and drug use. The impact of farmers' attitudes towards **mastitis** and employee training on the frequency of mastitis-related antibiotic drug use (intramammary; IMA and systemic; SYA) was investigated by Kayitsinga et al. (2017). Their results showed that farmers who believed that "bad luck" plays an important role in mastitis problems were more likely to apply IMA and farmers who financially penalized their employees in case of increased cell counts were more likely to apply SYA. Scherpenzeel et al. (2016) found that attitudes towards dry cow therapy and reduction of antibiotic usage in the animal industry were related to whether farmers were performing selective dry cow treatment (SDCT) instead of blanket dry cow treatment (BDCT) on their farms. Three attitudinal variables were found to impact on this decision: The beliefs that financial consequences was one of the most important negative aspects of reducing antibiotic usage and uncertainty whether a cow would recover from mastitis without antimicrobials were both related to a higher odds that farmers were applying BDCT on their farms. Similarly, Jones et al. (2015) investigated farmers' intention to reduce on-farm antibiotic usage over the next twelve month. Although the calculated overall attitude did not show to be related, single aspects like thinking that reducing antibiotic usage would be a good thing, would lower the costs and would increase consumer confidence in milk and milk products correlated positively with intention to reduce antibiotic usage. Vande Velde et al. (2015) found farmers' attitudes towards "anthelmintic drugs" and "nematode diagnostic methods" to be associated with farmers' intention to adopt **diagnostic methods before implementing anthelmintic drugs**. Negative attitudes towards diagnostics (constructed of the items Good-Bad, Useful-Useless and Beneficial-Harmful) showed to be negatively associated with uptake of diagnostics, while positive attitudes towards the use of anthelmintic drugs impacted positively on intention to perform previous diagnostics.

Investigating the impact of attitudes on human-animal-relationship Hemsworth et al. (2000) and Breuer et al. (2000) investigated the impact of farmers' attitudes towards **dairy cows on**

human behavior during milking. Breuer et al. (2000) found that positive attitudes were negatively correlated with the percentage of highly negative tactile interaction during milking and positively correlated with the proportion of quiet and soft vocalizations of farmers. Hemsworth et al. (2000) also revealed that stockpeoples' positive attitudes towards the behavior of dairy cows correlated negatively with the number of forceful tactile interactions during cow handling.

Concerning investigation of the uptake of general management aspects on dairy farms, Alemayehu et al. (2010) reported that Ethiopian farmers' preferable attitudes towards the production of indigenous Horo cattle was a determinant for the decision to choose that marked-oriented business. Questioning which factors might influence the adoption of improved grassland management among small-scale dairy farmers in Mexico, Martinez-Garcia et al. (2013) reported that positive attitudes towards that option (i.e. decrease of costs, increase of milk yield, easy to manage) promoted the uptake whereas negative attitudes (e.g. requires availability of land, investments are not recovers from milk sales) prevented farmers from using improved grassland. Using the same questionnaire items for attitude assessment and theoretical framework (i.e. Theory of reasoned action), Garforth et al. (2006) and Rehman et al. (2007), both showed that farmers' positive attitudes towards different approaches to better oestrus detection (e.g. cost effectiveness, better detection rates) lead to a higher intention to adopt recommended observation times, milk-progesterone test kits and use of pedometers on their farms.

DISCUSSION

Here, we have systematically reviewed research considering farmers' personality and attitudes as risk factors for dairy cattle health, welfare, productivity and farm management. Focus was on methodological approaches and whether overall contextual conclusions can be drawn on personalities' and attitudes' impact on outcome variables. We found methodological

approaches to be diverse, thus hindering in-depth overall conclusions. Nevertheless, the comparison of paper findings indicated that farmers' personality and attitudes impact on dairy cattle health, welfare, productivity and management. In general, attitudes indicating higher degrees of knowledge, affection with problems, perceived responsibility, perception of control of a situation, a more positive human-animal relationship and positive evaluation of the benefits of management decisions tended to impact in a beneficial way on outcomes. While attitudes were related to all thematic (outcome) areas, and personality measures were only reported to impact on management aspects and dairy productivity, over-interpretation regarding a possible predominance of their effect on specific dairy production areas must not be done.

The review approach

To date, as a consequence of expanding evidence based practice across all sectors, there is an increasing variety of review approaches (Grant et al., 2009). Scoping reviews, on the one hand, aim to identify nature and extent of research evidence by preliminary assessing potential size and scope of research literature. They characterize quantity and quality of literature by study design and other key features. On the other hand, systematic reviews focus on appraisal and synthesis of research evidence. These often adhere to guidelines on the conduct of a review and address uncertainty around findings, what remains unknown and develop recommendations for future research (Grant et al., 2009). Due to our objectives, we chose a mixed-method approach combining core aspects of systematic and scoping reviews as a tool for our investigations as we considered a mere quantification and quality assessment of literature as too superficial for the topic investigated. Per Grant et al. (2009), meta-analysis is listed as an own category in the context of reviews. It is supposed to statistically combine the results of studies aiming to a more precise effect of results. Meta-analytic results are based on numerical analysis of effects assuming absence of heterogeneity between reviewed papers. However, our results showed the reviewed papers not to be appropriate for such synthesis at the current stage.

Search strategy

The few references gathered from the reference lists of relevant publications indicated an efficient search strategy. By restricting publications to German and English, we may have missed publications. Grey literature and website searches were omitted. This would have been crucial for conduct of a meta-analysis, in which an overall effect is calculated based on the individual outcome of the identified articles (McAuley et al., 2000). However, due to the diversity of approaches, variables and outcomes in the reviewed papers, a meta-analysis was not feasible. Instead, our review only included peer-reviewed publications that were deemed appropriate by experts in the same field (Kelly et al., 2014) to describe the impact of attitude and personality as risk factors for dairy cattle health, welfare, productivity and farm management. Many publications were dismissed during paper selection as they considered attitude and personality as outcomes, reported only descriptive results, dealt with outcomes or species not meeting eligibility criteria or focused on the effectiveness of intervention on attitudes. These articles may have an important impact regarding their research field; however, they did not yield information we needed (i.e. results and discussion about the impact of attitude and personality as risk factors for dairy cattle health welfare, productivity and farm management).

We used well-known and evaluated methods and techniques to identify relevant literature and exclude irrelevant papers (e.g., Papaioannou et al., 2010). Nevertheless, the search strategy includes certain researcher specific decisions, for example on which concepts and keywords to include or not to include. To substantiate our decisions we discussed them with colleagues from the dairy herd health unit and librarians of our university. Nevertheless, it cannot be ignored that other researchers would have decided for slightly different keywords. Hence, this might have resulted in a slightly different list of papers. Therefore, we reported on the search strategy and our findings can only be related to this.

Spectrum of studies on personality and attitude as risk factors

Research on personality and attitude as risk factors for dairy health, welfare, productivity and management has involved researchers in many countries worldwide. We found that personality and attitude were investigated relative to their influence on management and dairy cattle health more frequently than on welfare and productivity (see Table 6 for attitude assessment). This might be because farmers' management decisions can be considered the basis for any activity implemented on farms and animal health is a basic requirement for achieving animal welfare and productivity. Another reason could be that management decisions and animal health parameters are easier to measure than welfare indicators and productivity, which require complex on-farm observations or analyzing secondary data such as production records.

Theoretical background and item disclosure. Transparency is an important feature of scientific research. Miguel et al. (2014) stressed the importance of open data and materials, especially in social science research. Open data and materials “provide the means for independent researchers to: reproduce reported results; test alternative specifications on the data; identify misreported or fraudulent results; reuse or adapt materials (e.g., survey instruments) for replication or extension of prior research and; better understand the interventions, measures and context – all of which are important for external validity” (Miguel et al., 2014). We concentrated on whether two main aspects that we deemed important in the context of our review were presented lucidly. These were (1) explanation of theoretical backgrounds (incl. psychological objects) for risk factor assessment and (2) disclosure of questionnaire items or interview questions used.

As theoretical backgrounds and items used to assess risk factors were not comprehensively reported in all records, future reporting might benefit from inclusion of more detailed information to enhance reproducibility and evaluation by independent researchers. Reporting the theoretical background, for example, increases the comprehensibility of study hypotheses.

TPB or TRA, which have been mentioned as theoretical backgrounds for assessing attitude, link factors that impact a person developing certain behavioral intentions. The person's attitude is one of these factors, which may therefore help to predict behavior (Ajzen, 2001). These theories are especially applicable when the dependent variable is a behavioral intention or an observed behavior (Fig. 3a). We investigated farm management as a thematic (outcome) area, and these theories can be directly applied to the impact of attitudes on farmers' behaviors or management decisions. However, most studies summarized in this review focused on outcome variables other than behavior or behavioral intentions (e.g., milk yield, prevalence of disease). Therefore, the analyzed risk factor and the outcome appeared to be indirectly related (Fig. 3b). For example, when assessing the relationship between an attitude such as "empathy with the dairy cows" and milk yield (Hanna et al., 2009; Fukasawa 2017), the hypothesis might be that a certain attitude influences the farmer towards a certain management decision, which itself increases or decreases the herd's milk yield. However, here the psychological object differs from the farmer's behavior, and the farmer's behavior itself is not assessed. Hence, this approach differs from the classical assessment of how attitude impacts behavior and this example illustrates why researchers should report the causal theory behind their hypotheses. When interpreting relationships between attitude and animal-related outcomes it should be considered to which psychological objects an attitude was assessed and which farmer's behavior is suggested to impact animal-related outcomes. As one result of this review was that the associations between attitudes, psychological objects and outcome were not always described in an easily comprehensible manner, visualization of the hypothesized associations may help to improve understanding (i.e. by use of causal diagrams; Dohoo, 2009). Here, all factors involved in the causal situation can be included, even those not analyzed.

Disclosing the items used to collect data is also important for ensuring clarity, particularly as no fixed item sets exist for assessing attitude, in contrast to personality. According to Schwarz

(2001), a question's answer or a statement's rating can be influenced by small changes in an item's wording or an answer scale's design. As attitudes towards identical psychological objects can be assessed using different items, we encourage reporting questionnaire items to facilitate comparing and interpreting results.

Data collection. In the studies included here, **personality** was assessed most often by those personality domains included in the Five-Factor model. However, the nomenclature in these domains was inconsistent between the articles (Table 4). This might be because the nomenclature differs even in the socio-psychologic literature. Therefore, it may be beneficial to develop harmonized nomenclature, at least within specific research fields (i.e., dairy science). Of course, the issue of nomenclature is not only apparent in this field of research. For example, different nomenclature and scoring systems exist for the assessment of lameness conditions in cattle (Penev, 2011).

Well-established and broadly accepted personality assessment theories exist, such as the Big-Five or HEXACO. Item sets to assess personality domains are freely available and have been scientifically validated in different languages (Goldberg et al., 2006). These item sets contain different numbers of statements including validated short versions, which allow their use even when time or space is limited (Gosling et al., 2003; Ashton and Lee, 2009; de Vries, 2013); therefore, we believe that using unconventional, non-validated inventories should be avoided where possible, and if they are used this should be well-founded and explained.

In contrast to personality measures that are limited to a set number of theoretical domains and facets, no such limitation exists for **attitudes**. The variety of attitudes that can be investigated is as large as the number of psychological objects imaginable. The researcher must consider which and how many psychological objects (objects towards which attitude is assessed) are of interest regarding their possible influence on the dependent variables (farm-specific outcomes concerning animal health, welfare, productivity and management). Again, this highlights why

it so important to explain the theoretical background (e.g. by drawing a causal diagram; see discussion above). Furthermore, as can be seen from table 5, where we proposed generic terms and topics to subsume psychological objects, harmonization of terms and definitions regarding certain well-investigated psychological objects would, in general, be possible and could increase future overall discussion of study findings.

Information extraction and data processing. We focused on questioning the methods that the researchers chose. We did not evaluate whether the reported approaches were suitable for the data to which they were applied.

The common method for extracting **personality** data condenses several questionnaire items into a smaller number of personality dimensions. Using a validated inventory or item pool related to the Big-Five or HEXACO clearly defines which items code for which personality dimension. However, this is not the case when self-tailored question sets are used to assess personality. In these cases, clear descriptions of the data extraction method are needed to ensure comprehensibility and reproducibility (Miguel et al., 2014).

When assessing **attitudes**, the researcher must decide how to condense items. Principle component analysis was used most frequently for that purpose in the studies in this review. The nomenclature of the resulting attitude classes remains the researcher's decision. Using the same questionnaire items and operating partial correlation analysis for extraction, Hanna et al. (2009) extracted four attitude classes related to the psychological object "working with dairy cows" out of 42 questionnaire items ("empathy", "negative beliefs", "job satisfaction" and "patience"), while Fukasawa et al. (2017) extracted only three attitude classes and labeled one differently ("positive beliefs", "negative beliefs", "job satisfaction"). Hence, variation in procedures used to condense and deduce latent information may impair reproducibility. However, the fact that identical questionnaire items lead to different attitude classes supports our impression that

attitude assessment results cannot be compared at the most detailed level, at least not under the given conditions without standardization of generic terms for psychological objects and a precise description of the anticipated association between attitude, psychological object and outcome.

Risk factor analysis. Correlation and regression analyses were the methods used most frequently to analyze and interpret relations between farmers' personalities and outcomes. The process of classifying and interpreting the results differed in the parameters chosen to derive their significance and relevance. This heterogeneity is an obstacle to comparing the results and should be considered when interpreting them.

Relationship between personality and attitude and dairy cattle health, welfare, productivity and management

As 50% of the reviewed papers found personality influences, and 94% found attitude influences, we conclude that personality and attitude are likely to impact on aspects of dairy cattle health, welfare, productivity and farm management. However, we caution against over-interpretation of the finding that attitudes were related to all thematic (outcome) areas, while personality measures were only reported to impact management aspects and dairy productivity. One reason for this observation may be that the researchers' interests influenced their study hypotheses, and this should not be misinterpreted to imply that personality does not impact dairy health or welfare.

When considering whether an overall conclusion can be drawn regarding the impact of attitude and personality on dairy cattle health, welfare, productivity and management, we believe that the complexity and heterogeneity must be considered, especially regarding attitude. Whereas, a standardized and evaluated model and validated questionnaires exist for personality, there are diverse approaches to processing data, analyzing risk factors and interpreting results. This can hinder comparison of studies even on identical attitudes.

Publication bias should be considered, as researchers who revealed no relationships between risk factors and outcome variables may be less likely to have published their results (Ioannidis, 2005), or scientific journals may have preferentially published detected effects and significant results (Dohoo, 2009). Furthermore, the thematic outcome variable areas we investigated here may have been of differing interest for scientists, professionals or politicians in past years; therefore, they may have been excluded in scientific research to some degree. This may also have biased the information we could gather at this point. Finally, assuming that all observational studies considered in this review require voluntary participation it is also necessary to consider selection bias. Therefore, results of the published papers may not be universally valid for the source population but restricted to the study group (Dohoo, 2009).

The heterogeneity of the psychological objects assessed and the variable methods applied to collect, analyze and interpret data in attitude assessment impede development of a general overall conclusion of how attitudes impact dairy cattle health, welfare, productivity and management. However, the answer to the question of which attitude affects which outcomes depends on the details of the view. As we show farmers' attitude towards "working with dairy cows" impacts on dairy cattle health, welfare, productivity and management. However, each study extracted different information from different questionnaire items and extracted this information differently. Thus, diversity increases with the depth of detail. This issue, though, is not only apparent in attitude assessment. We discover this phenomenon also in other fields of veterinary science. For example the recording of infection diagnostics may span from qualitative (yes/no in culture) over quantitative (OD% in ELISA) records towards molecular typing in order to describe the detection of pathogens. This could result in similar problems comparing findings due to different levels of detail. Hence, we have to expand our attention regarding this problem from the risk factors to the outcome variables, as well. When comparing information from different levels of detail the most straightforward solution is to pull together information on the highest hierarchical level apparent (e.g. diagnostic test positive vs. negative).

Although this may result in a loss of interpretative depth, it enables suggestion of an overall conclusion. Within the review presented here this kind of higher level advance to compare study findings was applied especially on papers investigating farmers' attitudes as those showed the greatest amount of heterogeneity. As shown in table 5, it was possible to aggregate different psychological objects into topics. For that purpose it was necessary to consider the contextual meaning behind the detailed label of the psychological objects. In this case, the advance on a higher level of detail made it possible to come to overall conclusions. This points out the benefits of our detailed, framework-centered approach to this review: focusing on details of theoretical frameworks is necessary to understand and use the concepts properly; however, putting results in relation to practical use (i.e. what do we learn by summing up different research results) requires a wider view of results. Nevertheless, it has to be taken into consideration that comparing results of different papers on a higher level of detail might also lead to false overall conclusions.

Considering these methodological challenges this scoping review enabled some general overall conclusions regarding personality and attitude as possible risk factors for dairy cattle health, welfare, productivity and management.

Health. It is comprehensible that job satisfaction (i.e. evaluating the task of milking as positive) positively impacts on cell counts (Tarabla & Dodd, 1990), as milking is a task that is characterized by a high degree of routine and maybe even monotony. Therefore, high regard of the task may lead to more conscientious work and might positively affect hygiene and inspection of animals, which are important to prevent mastitis and recognize udder infection at an early stage. Another attitudinal aspect which has been shown to impact on the animals' health is the farmers' evaluation of the managerial on-farm situation. Being aware of shortcomings (Schewe et al., 2015), and knowing about important parts of farm management (Silverlas et al., 2013) is important to make proper management decisions. The findings of Schewe et al. (2015),

who reported that farmers seeing both, mastitis and not following protocols properly, as a problem was associated with higher cell counts, has to be interpreted carefully as regards the direction of the association. Normally, one would expect such awareness to be a good basis for a change within management to tackle the problem. However, farmers' perceptions could also result in self-fulfilling prophecies; or the awareness of the shortcomings may only be a result of high cell counts. Other factors reported to impact on animal health have to do with the empathic setting of the farmer. Thinking that animals feel pain as humans do (Kielland et al., 2010) indicates a high degree of emotional attachment to the animals and might result in better care. However, it was also observed that when a stillbirth from a heifer was regarded as less severe than a stillbirth from a cow, the farm health status might be affected negatively (Santman-Berends et al., 2014). Here, it becomes clear that farmers also have to consider economic factors, which may be evaluated superior to emotional attachment with animals by some stockpeople. Finally, the fact that farmers with higher odds of being a bTB case felt more often that other people or institutions could not help them with their problems, stresses the fact that proper information and support-strategies are crucial and this topic should be addressed by professionals and politicians.

Welfare. Results show that the concept of human-animal relationship is in the center of the investigation of attitudes' impact on animal welfare. Aversive cow behavior (flinches, steps, kicks in the milking parlor; Breuer et al., 2000) and avoidance distance within approach tests (De Roches et al., 2016) were shown to be influenced by farmers' attitudes towards the animals. Favorable attitudes resulted in better welfare. These results are in compliance with other research investigating human impact on stress in farmed animals (e.g. Hemsworth et al., 1989; Jones, 1993). It has to be noted that both, Breuer et al (2000) and De Roches et al. (2016), assess the impact of attitudes on welfare as part of a hypothesized causal chain finally aiming on assessments of effects on productivity. Therefore, these studies may be seen as good examples for proper construction of hypotheses and good reporting of theoretical backgrounds.

787 **Productivity.** It is easily comprehensible that emotionally labile farmers (i.e. neurotic persons;
788 Arias and Spinka, 2005) may affect the productivity of cows. This finding substantiates
789 Seabrook et al. (1972) who found certain traits (e.g. motives, emotion) to lead to decreased milk
790 yield. Anxious, angry or depressed persons may act accordingly when handling their animals.
791 Stressed cows may then show a decreased milk yield as the negative effect of stress on the
792 productivity of farmed animals has also been shown for various other species (Hemsworth et
793 al. 1981; Barnett et al., 1992; Cransberg et al. 2000; Hemsworth et al.; 2000). On the other hand
794 Hanna et al. (2009) could not find a personal characteristic like impatience to lead to decreased
795 milk yield. Therefore, it seems of critical importance not to over-interpret all improper behavior
796 of stockpersons as compulsory risk factors for milk yield. Animals can get used to different
797 kinds of persons and the level of stress might decrease as the animals have adopted to a certain
798 kind of handling for example (Grandin, 1997). Hence, it could be of special interest to think
799 about which other consequences might occur within the daily farm business, if the farmer scores
800 high for the above mentioned personality facets. Anger and depression might curb mental and
801 emotional resources, which again may lead to a decreased ability of stockpersons to keep an
802 overview on the needs of the animals and necessary tasks. It has been shown that feeling in
803 control of a situation impacts positively on performance (Vaarst & Sorensen, 2008; Jansen et
804 al., 2009). On the other hand, a lack of feeling in control can curb ones' ability to act upon the
805 real situation (Ajzen, 1991). In this context, being depressed could also result in the feeling of
806 losing control. This hypothesis corresponds with the findings that attitude can impact on milk
807 yield, as well (Hanna et al., 2009: "empathy"; Breuer et al., 1999 and Seabrook, 1972: "job
808 satisfaction"). Being satisfied with ones' job (i.e. working with dairy cows and being a farmer)
809 and holding positive beliefs about cows (Fukasawa et al., 2017) is a prerequisite for an open-
810 minded relationship with the animals, appropriate handling of cows (Hemsworth et al., 2000),
811 openness to technical further education (i.e. gain of knowledge) and awareness of shortcomings

or upcoming difficulties. The consequence can be proper management decisions. This might lead to less stressed and healthier cows and a higher milk yield.

Management. It is understandable that attitudes representing higher degrees of technical knowledge (Toma et al., 2015; Ritter et al., 2015) were shown to favorably mediate management decisions. Therefore, communication of knowledge (e.g. about characteristics of pathogens or aims of interventions) should be seen as an important aspect by professionals when providing farmers with advice. This is in compliance with the findings of Bruijnis et al. (2017) and Vande Velde et al. (2015) who revealed that farmers have to be convinced about the usefulness of management decisions to increase the odds of implementation. Beside these aspects farmers' management, decisions were shown to depend on economic considerations as well. Making management decisions, farmers evaluate cost effectiveness (Scherpenzeel et al., 2016; Jones et al., 2015; Martinez-Garcia, 2013), ease of management (Martinez-Garcia, 2013) and time constraints (Ritter et al., 2015). These findings highlight that farmers might see themselves in an area of conflict. This conflict is expressed in the wish to make the best decision for their farm and feeling responsible (Toma et al., 2015), on the one hand, and financial pressure and high workloads, on the other hand; this may be very pertinent as both financial pressure and workload have increased in the dairy sector within the past decades (do you have a reference for this). This conflict should also be kept in mind when evaluating effects related to job satisfaction and the issue of stress in daily farm business.

Overall Conclusion

We provide an overview of research on the impact of farmers' personalities and attitudes on dairy cattle health, welfare, productivity and farm management, focusing on the spectrum of studies as well as on the relationships between personality and attitude and the dependent variables.

Research, conducted in several countries, suggests that farmers' personalities and attitudes influence dairy cattle health, welfare, productivity and farm management. This effect was shown by more studies for attitude than for personality.

We believe that comparing manuscripts at a detailed level regarding the impact of certain attitudes and personality dimensions is impeded due to variable methods of collecting, analyzing and interpreting data, the heterogeneity of psychological objects assessed and the many dependent variables per thematic area investigated. Furthermore, reporting the theoretical backgrounds and disclosing (question) items should be improved. We therefore encourage full disclosure of materials, as well as consideration of ways to harmonize assessing attitudes and personality measures, to promote comparison and enhance interpretation of results.

However, comparison of papers on a less detailed level revealed that personality dimensions and attitudes indicating favorable traits and opinions are associated with better dairy cattle health, welfare, productivity and farm management. Therefore, further research on these farmer-intrinsic aspects and their consideration by professionals and decision-makers within the dairy sector and politics is strongly recommended. This might provide the chance to better understand the needs of dairy farmers and therefore develop tailored advice and support-strategies to improve both satisfactory and constructive cooperation.

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TABLES

Table 1. Concepts and keywords operated in the final database search in English

Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
farmer*	personalit*	welfare	dairy	relation*
stockperson*	„personal characteristics“	wellbeing	cow*	associat*
stockman*	attitude*	productivity	cattle	correlation*
herdsman / herdsmen		health*	calve*	influence*
producer*		management	heifer*	effect*
rancher*		performance		
smallholder*				

Columns are linked with Boolean AND-operators. Lines are linked with Boolean OR-operators.

* indicates wildcard operator allowing any number of additional letters.

Words in quotation marks are regarded as connected terms.

Table 2. Concepts and keywords operated in the final database search in German

Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Landwirt*	Persönlichkeit*	Wohlergehen	*kuh*	Einfluss
Nutztierhalter	Einstellung*	Tierwohl	*kühe	Einflüsse
		Produktivität	Milchvieh*	Korrelation*
		Management	*rind*	Verhältnis
			Kalb	Beziehung*
			Kälber*	Zusammenh*
			Färsen*	Assoz*

Columns are linked with Boolean AND-operators.

Lines are linked with Boolean OR-operators.

* indicates wildcard operator allowing any number of additional letters.

Words in quotation marks are regarded as connected terms.

Table 3. Numbers (n) of records per country (38 records included)

Country of research	Records (n)
United Kingdom	11
Netherlands	5
Norway	3
Australia	2
Austria	2
USA	3
Sweden	2
Finland	2
Denmark	2
Czech Republic	1
France	1
Canada	1
India	1
Ethiopia	1
Japan	1
New Zealand	1
Uruguay	1
Belgium	1
Mexico	1
Total	43*

*= one study included data from Norway, Sweden, Finland and Denmark. Another includes data from New Zealand and Uruguay.

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1087 Table 4. Personality domains assessed as named by the authors (four records included)

Personality domain	Records assessing this domain (n)
Extraversion	3
Agreeableness	3
Conscientiousness	3
Neuroticism	2
Emotional stability	1
Intellect	1
Agreeable	1
Confident extravert	1
Pessimistic	1
Openness to experience	1
Openness	1

1088 Table 5. Psychological objects and topics considered for attitude assessment (37 records included)¹

Attitude Topic	Psychological Object ²	Number of records ³ (n)
Dairy Cows	Statement: "Animals feel physical pain as humans do"	2
	Working with dairy cows	6
	Dairy cows	4
	Characteristics of dairy cows	4
	Interacting with dairy cows	1
	Productivity of local breeds	1
	Cattle (heifers)	1
Drug Use	Mastitis related antimicrobial agent use	2
	Anthelmintic drugs	1
	Reduction of antibiotic usage in the animal industry	1
	Dry cow therapy	1
	Use of antibiotics	1
Other Infectious Diseases	Bovine tuberculosis	1
	Johne's disease	1
	Alberta Johne's disease Initiative	1
	Nematode diagnostic methods	1
Mastitis/Udder Health	Mastitis	4
	Udder health	1
	Mastitis management	1
	Contacting a vet the same day when detecting mild clinical mastitis in a lactating cow	1
Calves	Calf mortality	2
	Calf rearing	1
	Calf disease	1
Biosecurity	Adoption of control measures for E. coli	1
	Biosecurity	3
Work Routines	Taking action to improve cow foot health	1
	Milking	1

	Using improved grassland	1
	Dairy production technologies	1
	Use of MDC recommended observation times for oestrus detection	2
	Use of podometers for oestrus detection	1
	Use of milk progesterone test kits for oestrus detection	1
Animal Welfare	Animal welfare	1
	Improving animal welfare	1
stockpersons' job	Stockperson's job	2

¹= as some papers investigated attitudes towards more than one psychological object, these papers are displayed more than once

²=Wording was taken over as presented in the records without any interpretation concerning textual meanings

³=Number of records assessing attitude towards that psychological object

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Table 6. Relationships between attitudes (towards different psychological objects) and dependent variables (sorted by thematic areas)

[illegible]

Psychological object considered "Attitude towards..."																																			Paper's citation*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
									X									X																	(Scherpenzeel et al., 2016)
																		X																	(Toma et al., 2015)
			X																X																(Toma et al., 2013)
																				X	X														(Vande Velde et al., 2015)
																							X												(Espetvedt et al., 2013)
																								X											(Martinez-Garcia et al., 2013)
																											X								(Jones et al., 2015)
																										X									(Rao et al., 1990)
																														X					Rehman et al., (2007)
																														X		X	X		Garforth et al., (2006)
		X		X																															(Breuer et al., 2000)
X	X																																		(Roches et al., 2016)
																													0						(Bertenshaw and Rowlinson, 2009)
																									X										(Kauppinen et al., 2013)
												X																							(Borne et al., 2014)
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		X		X																															(Schewe et al., 2015)
	X																																		(Jansen et al., 2009)
									X																										(Kielland et al., 2009)

Psychological object considered “Attitude towards...”																																			Paper’s citation*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
0																																			(Arias and Spinka, 2005)
X																																			(Broughan et al., 2016)
X																																			(Rouha-Mulleder et al., 2009)
X																																			(Tarabla and Dodd, 1990)
X																																			(Santman-Berends et al., 2014)
X																																			(Silverlas and Blanco-Penedo, 2013)
X																																			(Kielland et al., 2010)
X																																			(DeLong et al., 2017)

1= Dairy cows; 2= Working with dairy cows; 3= Mastitis; 4= Biosecurity; 5= Characteristics of dairy cows; 6= Mastitis related antimicrobial agent use; 7= Calf mortality; 8= Statement: "Animals feel physical pain as humans do"; 9= Interacting with dairy cows; 10= Reduction of antibiotic usage in the animal industry; 11= Taking action to improve cow foot health; 12= Udder health; 13= Stockperson's job; 14= Bovine tuberculosis; 15= Productivity of local breeds; 16= Johnes' disease; 17= Alberta Johnes' disease Initiative; 18= Calf rearing; 19= Dry cow therapy; 20= Adoption of control measures for *E. coli*; 21= Animal welfare; 22= Anthelmintic drugs; 23= Nematode diagnostic methods; 24= Milking; 25= Contacting a vet the same day when detecting mild clinical mastitis in a lactating cow; 26= Using improved grassland; 27= Improving animal welfare; 28= Dairy production technologies; 29= Calf disease; 30= Use of antibiotics; 31= Cattle (heifers); 32= using MDC recommended observation times for oestrus detection; 33= mastitis management; 34= using milk progesterone tests kits for oestrus detection; 35= using podometers for oestrus detection

X= relation reported between attitude and dependent variable

0= no relation reported between and dependent variable

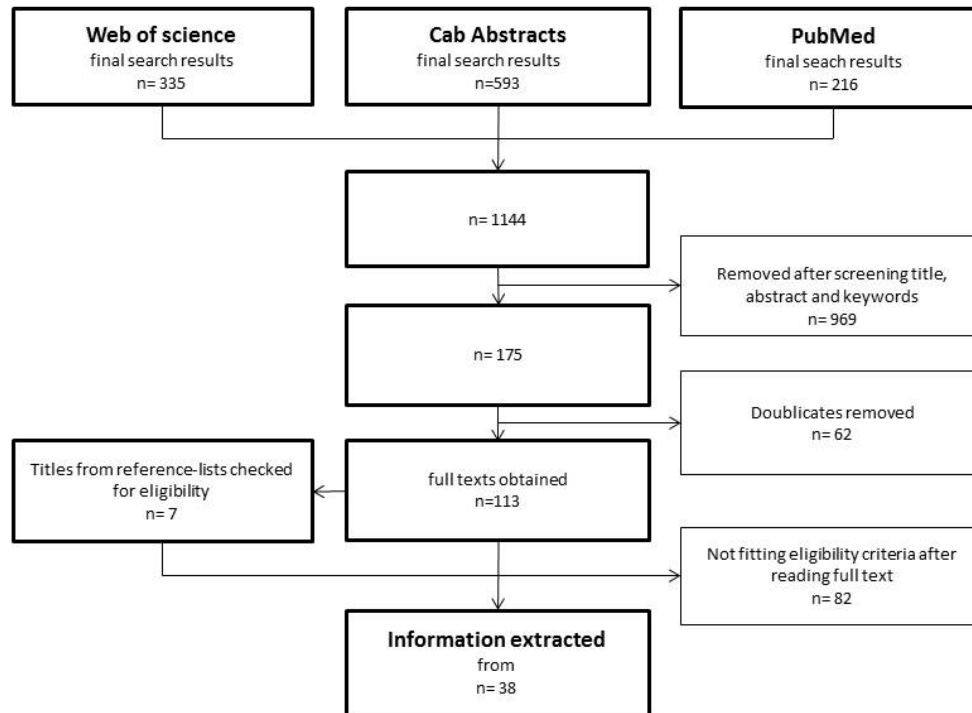
*As some papers investigate dependent variables from more than one thematic area these papers are displayed more than once.

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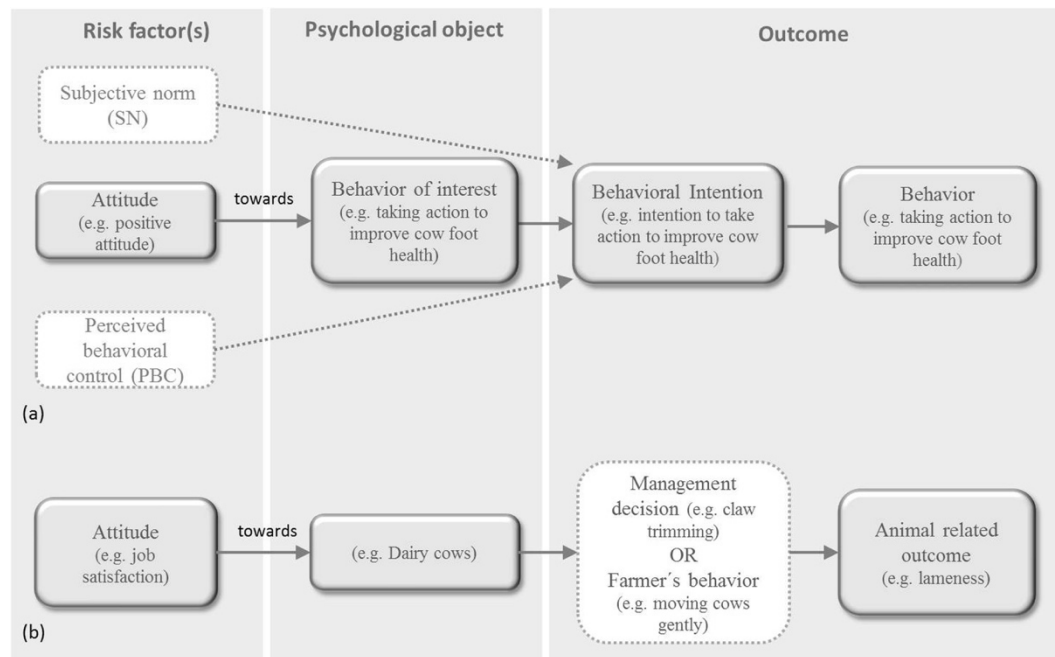
FIGURES

(Adler) Figure 1. Number of records captured in final database searches and removed at different stages of the paper selection process



1110

1111 (Adler) Figure 2. Causal Diagram to assess the impact of attitudes on an outcome; (a) Causal relation between
 1112 farmers' attitude and farmers' behavior, (b) Causal relation between farmers' attitude and animal related
 1113 outcome



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